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INSECTICIDES USED AT THE GRAY HERBARIUM.

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One of the questions most frequently asked by visitors at the Gray Herbarium is what means are employed to prevent the insect depredations to which all large collections of plants are to a greater or less extent exposed. This interest in the matter leads to the belief that it may be worth while to record the methods, which have been adopted, after a varied experience of many years, in dealing with this problem.

Until about 1885 it was the custom to poison with corrosive sublimate all specimens placed in the organized part of the Gray Herbarium. This was done in two ways. The first and crudest was to paint the specimens, after mounting, with an alcoholic solution of the sublimate, much to the disfigurement of the sheets. This way was soon abandoned as a general method and only resorted to in cases in which it was found that a sheet, already mounted, was infested by insects. The second method, used for many years, was to dip each dried plant, before mounting, into a shallow tray of the same solution and then dry it between blotters. This mode of procedure is, with various modifications, the one now followed in many private herbaria and in several of the great European collections. There is no doubt that it has a certain efficiency, but it also has considerable disadvantages. The slowness and expense of the treatment, while not burdensome in collections of moderate extent, become much more serious when the number of specimens mounts to many thousands annually. However, these are not the chief drawbacks. There is the difficulty of keeping an alcoholic solution at such a point of

density that it will be most effective and yet not deposit a perceptible coating of the sublimate upon the plant and thus alter the appearance of the surface, so that it loses to a certain extent its natural condition, so important in the identification of plants. In extreme cases it has been found that such a coating of sublimate may render it difficult to tell whether or not a given stem was glaucous in nature, or to determine with a hand lens the precise amount and character of minute pubescence. If, on the other hand, the density of the solution is allowed to sink much below saturation, a question arises whether the treatment is really effective. Many plants even in the dried state retain enough of their waxy super-cuticular coating to make it doubtful how thoroughly their tissues are reached by the solution during the brief wetting usually practiced. In this regard, however, it is to be admitted that an alcoholic solution would certainly be much more penetrating than an aqueous one.

There is an additional difficulty in this mode of poisoning from the fact that many dried plants, such as Potamogetons, aquatic Ranunculi, and others of delicate texture, quickly curl or become hopelessly tangled during an attempt to dip them into a solution of any kind. Other plants have a chlorophyll so delicate and tissues so easily penetrated by an alcoholic solution that they emerge from even a very short bath in a spotted and disfigured condition, the alcohol having partially exercised its well known solvent action upon the green coloring matter.

To prevent the curling of the specimens while they are drying after their bath, it is necessary, as already stated, to put them between driers, and these blotters draw off the greater part of the solution which the plants have taken up. Herein lies one of the chief reasons why the treatment is not more efficient, for it is probable that such parts of waxy-coated stems and leaves, as come into direct contact with the blotters, lose practically all the solution which may have adhered to them. Such exposed parts must become, especially after further cleansing, as for example through the friction of a towel during the process of mounting and the ordinary rubbing of superimposed sheets in the herbarium, vulnerable points for the attacks of the herbarium beetle. To overcome this difficulty, in some of the foreign herbaria, some more viscid substances and a small quantity of carbolic acid are added to the alcoholic solution of corrosive sublimate, rendering it more adhesive. However, this sort of perma-

nent more or less shellac-like coating over the specimens, even when very thin, affects the appearance of the surface.

A final annoyance in connection with the sublimate treatment arises from the circumstance that the substance is a violent poison to human beings as well as to insects. I am not aware that any case is on record of a person having been injured or even greatly annoyed by the use of corrosive sublimate in connection with an herbarium, although a physician once told me that he had experienced some irritation of the eyes while poisoning plants in this manner. However, although the danger to the amateur, whose herbarium work is confined to scattered hours of leisure, may be so slight as to be negligible, the question becomes more serious in a great herbarium in which an assistant would have to be engaged more or less continuously in such employment. The fact that corrosive sublimate is not a volatile substance doubtless much diminishes the danger, but in this connection it is to be remembered that during the changing of the driers and mounting of the plants subsequent to the dipping, many minute particles from the plants and driers are necessarily detached, forming a dust saturated with sublimate, which in this way must, to a considerable extent be inhaled by a person carrying on the work.

At the Gray Herbarium, however, it was not the difficulty, expense or even the danger (against which some expedients could probably be devised), which led to the abandonment of corrosive sublimate as an insecticide. It was its inefficiency. After many years experience with it Dr. Gray, annoyed by the poor results, declared with conscious hyperbole that the more the sublimate was used, the more insects came, — that they throve and grew fat on it.

About 1885 the sublimate was replaced at the Gray Herbarium by an alcoholic solution of acetate of arsenic. All plants added to the herbarium were dipped in this in the same way as above described for the sublimate solution. The acetate was selected from several salts of arsenic because of its deliquescent character, in consequence of which it was believed that it would be less likely to be detached as dust and render the atmosphere of the herbarium rooms unwholesome. This method was followed until 1890, when it was found on medical examination that two of the assistants, who had been suffering from some unknown irritation and general debility, had absorbed considerable quantities of arsenic, which in one instance had produced a temporary irritation of the kidneys. The

use of arsenic was then promptly given up and happily the physiological effects soon disappeared.

Thoroughly discouraged by the ineffectiveness and danger of the poisons hitherto employed, Dr. Sereno Watson, then in charge of the Herbarium, decided to give up the poisoning entirely, and to trust on the one hand to the tightness of the cases and on the other to the vigilance of the staff to protect the collection from insect depredations. After three or four years, however, it was found that both the small brown "herbarium beetle" (*Sitodrepa panicea*) and a more minute and colorless member of the Psocidae, the "book-louse" (*Atropos divinatoria*)[1] were increasing at an alarming rate and becoming pretty generally distributed in the collection. This was doubtless due in part to the fact that some large herbaria, acquired about that time, notably the collection of the late Dr. George Thurber, were badly infested by insects. In the injury to specimens at this period, it was clear that the recently inserted specimens, which had not received the corrosive sublimate or arsenic treatment, suffered most. This, however, cannot be taken as an unqualified proof of the value of these poisons, for many specimens of older date, known to have been so treated were found to be infested and injured by the insects, and the fact should be borne in mind that the first five years after the preparation of an herbarium specimen, before it reaches the final stage of complete desiccation, is the period when it is most liable to damage by insects.

The tightness of the cases, with the insects already inside, was naturally found to have only a negative value. Some more drastic means had to be found, and accordingly a tin can was devised for the fumigation of the sheets with carbon bisulphide. It was modelled upon a type of case successfully used by Mr. William Brewster in his valuable collection of birds, but was provided with eight shelves for herbarium sheets, of which it would hold about a thousand. The front of the case, which was also of tin, was provided on the edge with a metal phlange turning inward, which fitted into a metal groove in the case. This groove was lined with a convex strip of soft rubber, which being compressed by the phlange of the cover, when the latter was fastened on by ten external clasps, formed an essentially air-tight fitting. At the bottom of the can, under the lowest shelves, two spaces about two inches high were left for the insertion of shal-

[1] For the identification of these insects I am indebted to Mr. Samuel Henshaw.

low dishes of carbon bisulphide. About six or eight ounces of this were employed for each fumigation and the specimens were left in at least thirty-six and usually forty-eight hours. The effects were entirely satisfactory, so far as sure death to the insects was concerned; but it was soon found necessary to increase greatly the capacity of the apparatus, and four other cans, each capable of holding about two thousand sheets of specimens were installed. These were constructed upon the same plan, but the shallow pigeon-holes for the insertion of the sulphide were arranged at the top instead of the bottom, on the theory that the vapor of carbon bisulphide, being somewhat heavier than air would diffuse more effectively downward than upward. In regard to this point, it may be said that diffusion, although of unequal rate would doubtless occur effectively in both directions, and that theoretically it would be best to insert the sulphide somewhere about a fourth of the distance from the top to the bottom.

Working with the apparatus above described the staff of the herbarium fumigated the entire organized collection and the stored bundles of unworked specimens. Although the mere manual labor of the undertaking was considerable, the results were very repaying. For some months the herbarium was, so far as could be ascertained, entirely free from insects. After a year or so, a rare and sporadic reappearance of the herbarium beetle, led to a refumigation of considerable portions of the collection. Although since the use of the carbon bisulphide method, the number and depredations of the herbarium insects has certainly been reduced by 95 %, it has been thought best to employ in conjunction with this treatment some other precautions. An entomologist who was consulted said that the book-louse could be successfully kept out of any case by the use of camphor, naphthalin or, in fact, any agent producing a strong odor. In accordance with this suggestion flake naphthalin was purchased in large quantity and liberally sprinkled in each pigeon-hole of the herbarium cases. This was done immediately after the cases had been carefully cleaned while the specimens had been removed for their treatment with carbon bisulphide, the naphthalin being left in the cases when the herbarium specimens were replaced on the shelves. At the outset there was considerable scepticism regarding the value of naphthalin, but there is now good reason to believe that by discouraging a new immigration of insects, it is a useful adjunct to the carbon bisul-

phide treatment, especially in packages which are for any reason to be stored some months without opening.

Early in our battle with insects, it was felt that they would find a particular stronghold in what is known as the "bundle-room", where duplicates, unworked collections, etc., are kept, often for considerable periods, in separate packages. Accordingly, special precautions were taken with this room. All material was removed from it and the floors, standing woodwork and shelves were painted over with a nearly saturated alcoholic solution of corrosive sublimate — a treatment not to be recommended where woodwork is highly finished or its appearance a matter of consequence. This was done with the idea of sterilizing as far as possible any accumulations of organic dust, which might have lodged in the cracks of the woodwork in a manner to form food for insects. The packages were then brought back to this room only after a fumigation of at least forty-eight hours in the vapor of carbon bisulphide. Each package, tied in a preliminary manner, received a handful of flake naphthalin well sprinkled in among its sheets and was then securely wrapped in stout manila paper, tied, tagged, and placed on the sterilized shelves. This was done some years ago and the results have been most satisfactory. In fact, I am not aware that a live insect has been detected in the bundle-room since.

Even after the efficiency of these methods had thus been amply demonstrated, there was much left to be desired. Fumigation with carbon bisulphide is of necessity an annoying process from the extremely disagreeable and penetrating odor; and even if the cans or tanks, in which the fumigation is effected, are kept at a distance from the main rooms of the herbarium, the sheets retain for some days the odor, which is scarcely less disagreeable as it becomes fainter. The farther away the fumigating tanks are kept, the greater the labor of transporting the thousands of packages of herbarium sheets from the cases to the tanks and back again. To avoid the wear and tear upon the specimens, as well as to save much time and trouble, the attempt was made to fumigate the herbarium sheets directly in the wooden cases, where they are kept. This, however, proved a failure. Although about two pounds of the sulphide was used in a tightly closing twenty-six pigeon hole case and fumigation prolonged forty eight hours, it was found that living larvae of the herbarium beetle, which had been previously inserted among sheets in the case, although

apparently dead when taken out, became active again after two or three hours in air and sunshine. It is thus clear that carbon bisulphide fumigation to be effective must be conducted in metal cases.

Partly for this reason and partly with a view to the improvement of the fire precautions at the Gray Herbarium, much thought was devoted to the construction of a case for ordinary use in the herbarium, which should be at once gas-tight and fireproof. These features, which seemed simple enough, proved in combination rather difficult to realize, especially in a case which must open and close readily. After the supposed advantages of an all-metal case and a wooden case covered outside and in with sheet iron had been carefully weighed, sixteen trial cases of the second type were installed about a year ago. The doors, hinged at the side as usual, closed upon a continuous soft rubber buffer to render the fitting as air-tight as possible. These cases have proved satisfactory for purposes of fumigation, although they cannot be regarded as absolutely air-tight, a relatively small quantity of the vapor of the sulphide escaping around the doors. It is believed that they are also as fire-proof as cases can well be made. Unfortunately, however, it has been found impossible to treat the tinned sheet-iron covering in any way which does not make the case a crude and unsightly object. When, during the spring of the present year, it was again necessary to add a block of cases it was decided to have them made entirely of sheet steel, the plates of metal, wherever they came on the outside, being double with an air space of about five eighths of an inch intervening. This feature not only adds, on the well known principle of the hollow column, much strength to the structure as a whole, but is believed to insure practically as great protection against fire as the metal-covered wooden construction. Through the generosity of a liberal but anonymous friend of the Gray Herbarium it has been possible to have a trial block of eight such steel cases manufactured and recently set up in the main working room. They were made by the Art Metal Construction Company of Jamestown, New York, and the Gray Herbarium is much indebted to Messrs. Hine and Sullivan, the Boston representatives of the company, for their painstaking attention to this new application of their methods in steel work. In these cases, as in many safes, the doors fit with pressure against a smooth strip of piano felt, making a junction which is probably quite as effective as the rubber buffer above mentioned. The cases are handsomely japanned in light gray, are

provided with very firm and easy working latches, securing the door in three places at once, and are believed to represent an ideal herbarium case, so far as the subject is at present understood.

Since the instalment of the metal-covered and all-metal cases, much fumigation has been carried on in them. Of course, the great quantity of carbon bisulphide, which it is necessary to employ in cases of this size (twenty-six six-inch pigeon holes each)[1] would render any room disagreeable, and it is found desirable to carry on the fumigation during the summer vacation when students are away and the regular staff reduced to a minimum. However, if the ideal time ever comes when the whole of the great collection can be thus enclosed in metal, only rare fumigations will be necessary and these can be accomplished with the least possible difficulty.

The use of rubber buffers in closing a can employed for carbon bisulphide fumigation may be a surprise to those who recollect that this agent is a solvent for rubber. Experience, however, shows that the *vapor* of the sulphide exercises no appreciable injury to the rubber, which remains soft and pliant for a longer time than would be supposed.

The odor of carbon bisulphide, notwithstanding all the precautions which could be employed, being a great annoyance, experiments were undertaken with formaldehyde. In these Professor Charles Harrington of the Harvard Medical School, well known as an expert on the subject of disinfectants, was consulted and obligingly gave counsel and aid. The fumigation was carried on in one of the tin tanks with a capacity of about fifteen cubic feet, provided with a tin door closing against a soft rubber strip, thus essentially air-tight. The formaldehyde was produced first by the incomplete combustion of wood alcohol, then, in subsequent experiments, by volatilizing with an alcohol lamp the well known pastilles commonly used in disinfecting. The quantity of vapor produced in each manner was far in excess of the amount which experiment has shown ample to destroy disease germs. Owing to the successful work of the carbon bisulphide method, which had been in use many months, it was found impossible to obtain in the Gray Herbarium any living specimens of the "herbarium beetle" on which to try the effects of the formaldehyde fumigation, and *aphides* from the greenhouses were used instead. The surprising result was

[1] About two pounds in each case.

obtained that these soft, sluggish, and supposably non-resistent creatures came out of a formaldehyde fumigation of many hours duration without any apparent injury, although the same treatment is known to kill with certainty the bacterial germs of anthrax, diphtheria, etc. From these experiments, it was inferred that, however valuable as a disinfectant, formaldehyde would be likely to prove an unsatisfactory insecticide, and further experimentation with it was accordingly abandoned. Others, by varying the method, may have greater success with it.

In using carbon bisulphide, it should always be borne in mind that it is one of the most inflammable liquids known and that its vapor forms highly explosive mixtures with air. It is accordingly of the utmost importance for safety to keep both the liquid and vapor far from fire in any form or indeed from any source of heat, instances being on record in which carbon bisulphide has been ignited by the heat of steam pipes. It goes without saying that no match should be struck, lamp burned, or fire used in any manner in a room in which the fumigation is being conducted. The possibility of this easily inflammable agent acting chemically upon other substances employed in herbarium work and causing a heat-producing reaction sufficient to produce ignition, was early considered at the Gray Herbarium, and expert chemical advice sought. Happily, no such reaction appears possible with the other substances used. Where carbon bisulphide is to be used in quantity, it is a desirable precaution to store it in a remote out-building, bringing to the herbarium from time to time only such amounts as are to be used at once. The sulphide employed at the Gray Herbarium is kept in a small tool-shed at the back of the Botanic Garden. Some years ago it was kept in an old shed under a disused water tank, but one day the whole structure suddenly collapsing freed many pounds of the sulphide, which for some hours threatened an unwelcome fumigation to the entire neighborhood.

At the Gray Herbarium it has been found that no large group of vascular plants seems entirely immune from the attacks of insects. Probably the sedges are as little in danger as any; grasses and ferns also, if kept in perfectly dry cases are little subject to such injury, although one of the worst cases of insect work which has come to attention was on a collection of ferns stored for some years in Trinidad, doubtless in a damp atmosphere. Plants with a milky juice and

saprophytes seem especially attractive to insects. The Leguminosae and herbaceous Liliaceae also form vulnerable spots in an herbarium. In such groups as the Coniferae and Typhaceae, the staminate inflorescence is the chief point of attack.

The "herbarium beetle" is capable of eating almost any part of the plant, and includes lignescent stems and sometimes glue or even portions of the herbarium sheet in its diet. The book-louse, on the other hand, being especially attracted by pasty or saccharine substances, confines its injuries to delicate parts of the flower, chiefly the petals, anthers, and nectaries.[1]

Besides the insects mentioned, there are others peculiar to certain groups of plants, such as the gentians, irises, Peltandra, etc. These creatures, deposited as eggs in the base of the flower during the life of the plant, are apt to cause considerable annoyance by their ravages during and shortly after the drying of the specimen. The expedient of a short bath in steam or boiling water is only partially successful, since it usually results in a discolored or otherwise damaged specimen. How best to combat these most insidious insect enemies is a problem, to which it is hoped some amateur with leisure for experimentation and a taste for the refinements of herbarium technique may turn his attention. Probably the simplest way to avoid the difficulty in the case of the particular plants is to prepare specimens in some quantity and discard those injured while drying.

The burning of sulphur, practiced at some herbaria, to destroy insects, has never been tried at the Gray Herbarium, as it is difficult to feel quite satisfied that the methods ordinarily employed can be applied on a large scale without a slight fire danger. Furthermore, sulphurous acid exercises a strong bleaching action, and would be likely to affect the ink of the labels, even if not the plants themselves.

While the results of the experiments at the Gray Herbarium force us somewhat reluctantly to the belief that carbon bisulphide fumigation is the most efficient means of preventing insect depredations in herbaria of large size, I would not be taken as discouraging those who are employing corrosive sublimate. Several amateur botanists, with excellently appointed herbaria, ranging from ten to fifty thousand sheets, have told me that they have found the corrosive sublimate bath

[1] The carpet beetle (*Anthrenus varius*) and its larvae are occasionally found among herbarium sheets, but it has not been possible to ascertain whether it does any damage to the plants.

a perfectly satisfactory safeguard. On the other hand, I have recently learned with surprise that carbon bisulphide fumigation has been found ineffective in at least one herbarium of great size. This leads to the conclusion that, whatever method is adopted, success must come largely from care and thoroughness in its application. The danger from insects must be considerably greater in old buildings, and reduced to a minimum in new ones of modern construction with concrete floors and metal shelves. In any case, scrupulous neatness should be maintained in the surroundings of an herbarium. No accumulations of dust should be allowed on tables or shelves; dust-filled cracks in woodwork should be sterilized; all mouldy, imperfectly dried, or otherwise useless material should be promptly removed; and finally special attention should be taken to prevent the insect life in packages of stored duplicates, etc.

As efficient as the carbon bisulphide method has proved, its annoyance and danger are such as to stimulate investigations in other directions and at the suggestion of Professor W. E. Burke of the Engineering Department of Harvard University, some interesting experiments are being undertaken in the use of vacuum as a means of destroying insects. If it can only be demonstrated, that insects cannot survive in ordinary vacuum or, to speak more precisely, in an extremely attenuated atmosphere, much may be hoped from such a substitute for fumigation. Surely no other penetrating fatal agent could combine more happily so many desirable negative traits, such as perfect freedom from odor, poisonous fumes, and bleaching action, as well as from explosive, inflammable, or other qualities likely to render the herbarium rooms disagreeable or dangerous.

Gray Herbarium.

A NEW KOBRESIA IN THE AROOSTOOK VALLEY.

M. L. Fernald.

On June 29, 1899, the Josselyn Botanical Society of Maine spent the forenoon on the south bank of the Aroostook River at Fort Fairfield, Maine; and among other interesting plants collected by them was a slender wiry sedge first noticed by Miss Mabel P. Cook near the little spring above the long bridge over the Aroostook River. At